GLOBAL SHAPE AND REGIONAL TOPOGRAPHY OF IO: FIRST GALILEO RESULTS.

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Introduction

Galileo CCD images of Io are much superior in their geometrical precision to the vidicon images obtained by Voyager. In addition, the viewing angles obtained from Galileo in Jupiter orbit yield a more homogeneous coverage of Io's surface than could be obtained during the Voyager fly-bys. Hence, these new data allow us to carry out analyses to determine Io's morphology using a variety of methods, such as control point network analysis, limb studies, stereo image processing, and shadow-length measurements. While complementary studies on Io's morphology are discussed in companion papers [1,2,3], we focus on control point and stereo analyses in this study. Global shape models may give important boundary conditions for studies of internal structure from theoretical modelling of planetary shapes in tidal equilibrium and gravity data [4,5,6], whereas regional topography may reveal the structure of the crust and variations in conductive heat flow [7].

Global Shape

A "Plume Monitoring" image sequence was obtained in August 1996. The set of 31 images, taken from almost within Io's equatorial plane, provide multiple uniform global coverage and therefore appear well suited for control point network analysis. For photogrammetric purposes, however, these images, taken through a violet filter, have several shortcomings: 1) they are of low resolution (from 13 to 31 km/pixel), 2) the high compression ratio contributes artifacts to the images, 3) the images were taken under a range of differing phase angles of up to 82°, and 4) the images were underexposed to maintain low smear.

We handpicked 120 control points ("landmarks") on images from this sequence and measured their 1638 individual line/sample coordinates. On average, each control point could be identified in 14 images. A "bundle block adjustment" [4,8] was used to simultaneously adjust the camera pointing and spacecraft position data, and to determine the three-dimensional object coordinates for these control points. Three obvious outliers were removed from the data set during the adjustment.

The resulting individual x,y, and z coordinates have precisions of 15.8, 18.8, and 7.2 km, respectively, with residual errors of image coordinates being +/- 0.5 pixels. We calculated best-fit three-axial ellipsoids to describe Io's global shape, and find a=1835, b=1821, c=1814 km, however, with errors as large as +/- 4 km. These parameters are in agreement with previous estimates of Io's global shape from Voyager images [7] and from first Io limb studies using the new Galileo images [1]. Our still very preliminary models will be greatly improved once higher-resolution data collected earlier in the mission and new data collected in December 1996 and 1997 are included in our analysis.

Regional Topography

A "Topographic Mapping" image series was obtained in December 1996 and includes 7 clear-filter images at resolutions ranging from 2.5 to 4.1 km/pixel which cover surface longitudes from 90 to 320°. Phase angles vary between 32 and 61°. Although designed for mapping at high illumination angles, a number of these images offer repeated coverage of regions from camera positions separated enough to offer the opportunity for stereo viewing and digital stereo analysis.

Selected areas of these images were subjected to digital image matching to automatically produce large numbers of conjugate points [8]. Ray tracing was used to find three-dimensional object coordinates for these matched points. Object points were then converted to points in a map of sinusoidal projection and interpolated to form a contiguous grid. For the matching large, (>15 pixel diameter) patch sizes (correlation windows) were used in order to cope with image noise due to cosmic ray hits and the often low-texture terrain.

Three individual DTMs were derived in areas around Marduk (lat. -60° – +20°, lon. 190° – 220°), near Volund / east of Volund (lat. 0° – +45°, lon. 130° – 180°), and near Pele / north-east of Pele (lat. -30° – +20°, lon. 215° – 265°) with horizontal grid spacings of 30 km. Maximum heights from Voyager shadows are 10 km; here, elevation differences are typically 3 – 4 km with uncertainties in height of about 500 m. Visual inspection of the stereo images and inspection of these preliminary DTMs reveals distinct topographic highs amidst wide plains; these appear to represent volcanic constructs modified by gravitational collaps. However, there is little correlation of mountains with any of the active or recently active volcanic centers. Some of the topography visible is not evident in the form of shadows or albedo patterns. These observations are consistent with the expectation that albedo patterns are due to thin surficial deposits.

References:

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